SOUTER, T. G. 1927. Bird Notes. *South Austr. Ornithol.*, 9: 70-71.
STEINER, H. 1955. Das Brutverhalten der Prachtfinken, Sperm-estidae, als Ausdruck ihres selbständigen Familiencharakters. *Acta XI Congr. Int. Orn. 1954*, Basel. pp. 350-355.
SUTTON, J. 1957. A Week in the Robe District. *South Austr. Ornithol.*: 9: 5-29.
SUTTON, J. 1927. Bird Notes. *South Austr. Ornithol.*, 9: 35-44.
TARR, H. E. 1948. A Note on the Red-eared Firetail. *Emu*, 48: 161.
WARHAM, J. 1954. Red-eared Firetail. *Emu*, 54: 69-70.
WOLTERS, H. E. 1957. Die Klassifikation der Weberfinken (Estrildidae). *Bonner Zool. Beitr.*, 8: 90-129.

LATE QUATERNARY CHANGES IN THE VEGETATION ON ROTTNEST ISLAND.

By D. M. CHURCHILL, Botany Department, University of Western Australia.

The present vegetation on Rottnest Island has been described by Storr, Green and Churchill (1959) as a *coastal complex* made up of fairly open microphyllous shrubs in the coastal dunes; 10-20 foot high *Acacia rostellifera* scrubs in the sheltered valleys and slopes; closed mixed shrubs of the limestone ridges; and salt marsh communities around the lakes and swamps. During white settlement, prior to administration by the Rottnest Island Board of Control, widespread destruction of the vegetation took place through clearing for agriculture, chopping down trees for building and firewood, and unchecked burning which followed firing of the scrubs for Quokka shooting. The *Acacia rostellifera* scrubs were reduced to isolated thickets, and where the scrub once stood there now occurs a low dense formation consisting of sclerophyllous monocotyledonous plants, of which *Acanthocarpus preissi* and *Stipa variabilis* are the most prominent. The present balance between the *Acanthocarpus-Stipa* formation and *Acacia* scrub is controlled by fire frequency and intensity of Quokka grazing.

From the foregoing account it is evident that considerable changes to the vegetation have taken place on Rottnest Island over the last one hundred and fifty years. These changes may be attributed both directly and indirectly to the influence of white settlement. It is the purpose of this paper to give an account of the prehistoric changes in the vegetation that have occurred since the isolation of Rottnest as an island between 4,000 and 5,000 years B.C.

FOSSIL EVIDENCE

During the reorganisation of the fossil plant collections at the Western Australian Museum, the attention of the author was drawn to a specimen which consisted of the fibrous pith of the apical meristem of a Blackboy (*Xanthorrhoea* sp.). This specimen (Fig. 1) (Museum No. G9066) came from sediments encountered 19 feet below the surface, when a well was sunk at Rottnest Island, and was given to the Museum by Mr. A. Armit. No Blackboys have been found on the island since white settlement, and as

this specimen showed no sign of replacement by inorganic carbonate, the Botany Department of the University undertook to have the material radiocarbon dated. The New Zealand D.S.I.R. Division of Nuclear Sciences, which made the analysis, gave the age of the Blackboy as 7,090 ± 115 years before 1960 (B.P.).

Examination of the present ecology of Blackboys on the coastal mainland opposite Rottnest Island showed that they are confined to sheltered habitats on stable soils in the Tuart and Jarrah Woodland, and further north they are found on sheltered slopes in heaths, well back from the coast. Evidence of their high resistance to disturbance by clearing, burning and competition from introduced weeds, may be seen along the sides of the railway tracks between Perth and Fremantle, where they are the most common remnant of the native plants. At no place have Blackboys been found in habitats exposed to salt pruning by the wind, on shifting sands, or in the *coastal complex* of *Acacia rostellifera* and *Olearia* dominated scrubs. These latter scrubs, often on stable soils, are a characteristic facies of the present vegetation on Rottnest. It seems reasonable to infer that lack of protection from exposure to salt pruning by the wind has caused the extinction of Blackboys on Rottnest Island. Whether or not they were protected in 5,000 B.C. by woodlands or distance from the sea will be discussed later.

The only other plant macrofossil from Rottnest Island is a specimen of *Callitris* wood from the Rottnest shell beds. This specimen, shown to the author for identification, was found by Messrs. C. W. Hassell and E. S. W. Kneebone during their investigations on the geology of the island. Radiocarbon dates from these beds show that its age is 3,950 ± 130 years B.P., thus showing that *Callitris* has been on the island since at least 2,000 B.C. Abundant fossil pollen in the swamp sediments shows that *Callitris* has been

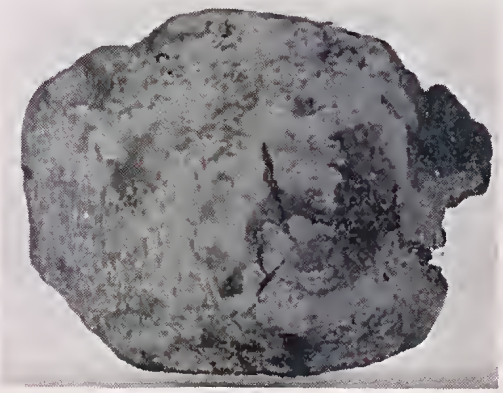

Fig. 1.—Fossil Blackboy (*Xanthorrhoea* sp.), 7,090 ± 115 years old. Note the concentric rings of the leaf scars around the domed apex. This Blackboy was growing at Rottnest only a few hundred years before rising sea level isolated the area as an island. Diameter of stem, approx. 6 inches.

on the island since then, and its recent near extinction has been due to the heavy cutting of the tree for timber.

Fossil pollen, preserved in the swamp peats and calcareous gyttja sediments, shows the continuity of change in the floristic composition of the vegetation on Rottnest, probably since 2,000 or 3,000 B.C. The origin of the pollen preserved in these sediments must first be understood before interpreting changes in the pollen record. Did the pollen come from plants growing on Rottnest or from windborne pollen carried from plants on the mainland? To solve this problem, atmospheric pollen was collected at the Rottnest research station and compared with atmospheric pollen collected on the mainland, and with fossil pollen from Lake Serpentine and Lighthouse swamp on Rottnest Island. Table I contains an analysis of the relative proportions of the different pollen sporomorphs.

TABLE I.—RELATIVE PROPORTION OF POLLEN SPOROMORPHS OCCURRING IN THE AIR ON ROTTNEST; IN THE AIR ON THE ADJACENT MAINLAND; AND IN THE FOSSIL STATE IN THE SWAMP SEDIMENTS OF SERPENTINE LAKE AND LIGHTHOUSE SWAMP.

Pollen Sporomorph	Atmospheric Pollen		Fossil Pollen
	Mainland	Rottnest	Rottnest
	%	%	%
Grass	24	69	1
Callitris	2	7	15
Pinus	26	5	—
Eucalyptus	9	4	3
Compositeae	3	3	6
Casuarina	5	3	2
Acacia	< 1	2	—
Unknown	—	2	2
Cyperaceae	—	1	19
Restionaceae	—	1	2
Adenanthos-Stirlingia	< 1	< 1	< 1
Liliaceae	—	< 1	< 1
Gyrostemon	—	< 1	—
Chenopodiaceae	—	< 1	36
Melaleuca	—	< 1	< 1
Halorhagus	—	< 1	—
Dryandra-Banksia	< 1	< 1	1
Euphorbiaceae	—	—	5
Macrozamia	—	—	1
Agonis	3	—	1
Rutaecae	—	—	< 1
Juneaceae	—	—	4
Others	25	—	—
Number of pollen grains counted	16,881	1,161	571

The pollen preserved in the swamps comes from two sources: first from the atmospheric pollen rain and second from pollen washed into the swamp. Where the relative frequency of the fossil pollen is lower than the Rottnest atmospheric pollen, as occurs in the grasses, we must assume either that the grass pollen has been destroyed in the sediments or that its abundance in the atmosphere is very recent. It is clear that grass pollen is preserved in the swamp sediments and in the profile from Lighthouse swamp (Fig.

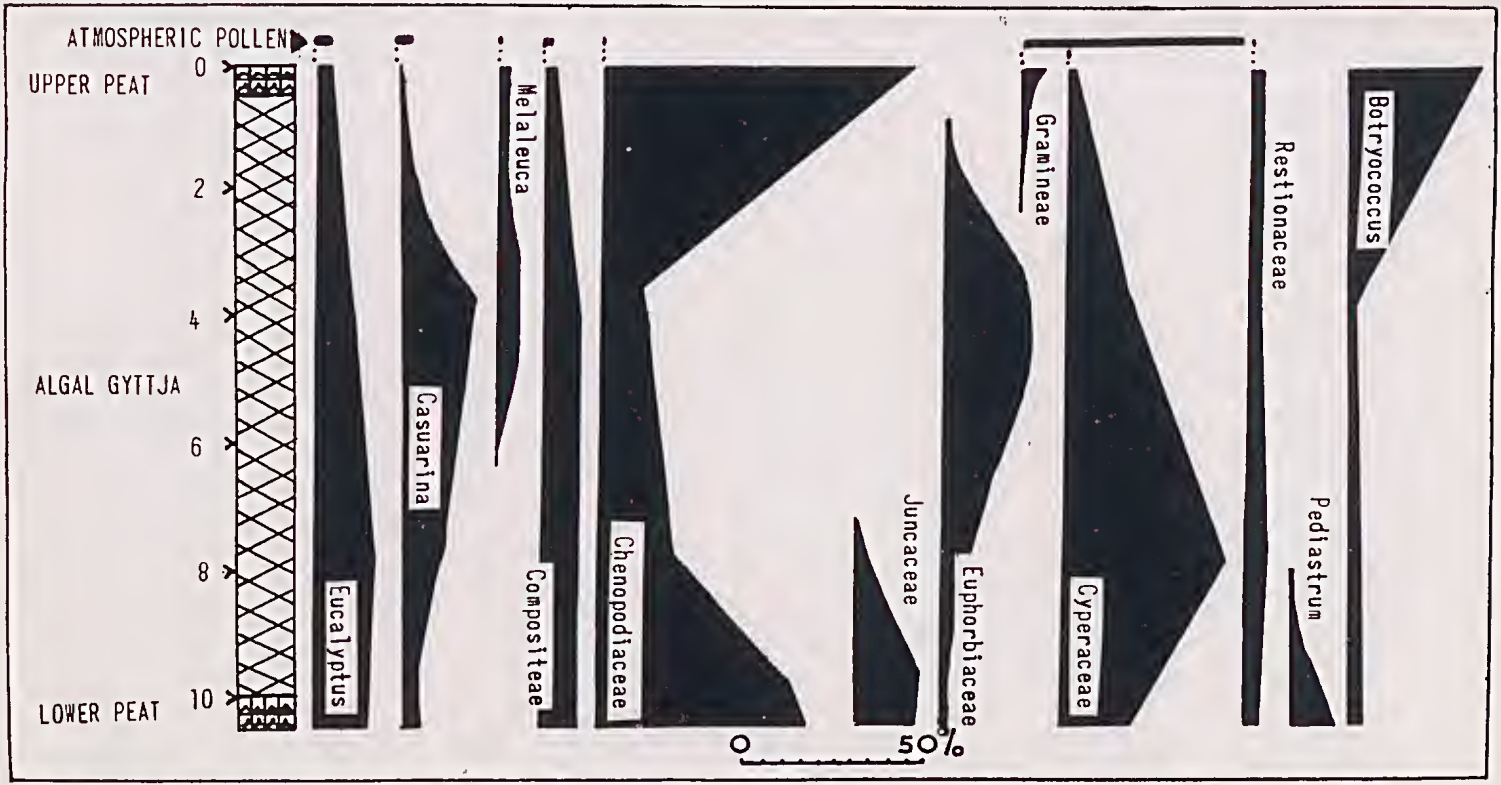

Fig. 2.—Pollen diagram from Lighthouse swamp, showing the relative frequencies of selected plants over an estimated 4,000 or 5,000 years.

2) is found only in the upper layers, thus indicating their recent prominence in the vegetation.

Where the relative frequency shows no significant difference between the fossil pollen and the atmospheric pollen it becomes impossible to say whether or not the pollen has been derived from plants on Rottnest Island or the mainland. Atmospheric pollen collected at Rottnest is derived from plants on Rottnest as well as on the mainland.

Where the relative frequency of the fossil pollen is significantly higher than that found in the atmospheric pollen, e.g., with the Compositeae, Cyperaceae, Juncaceae, Chenopodiaceae, Euphorbiaceae and *Macrozamia*, then, to account for the very high numbers in the sediments, plants from these families must have lived on the island at the time of pollen deposition.

The pollen diagram (Fig. 2) shows the history of certain plants over the last 4,000 or 5,000 years. From this record the following factors are evident:—

1. Peat deposition began in these swamps when they held open areas of fresh water, a condition no longer found on the island. These conditions are indicated by the planktonic freshwater alga, *Pediastrum*, which flourished during this period of peat deposition, but later died out.
2. *Juncus* (probably *J. maritimus*) was also abundant during this early period but later died out. This species, except for a single small stand near the Government House Lake, is now extinct.
3. The eucalypts show a gradual decrease throughout the sedimentary record. Their recent introduction to the island, however, has increased the amount of atmospheric pollen at Rottnest and if we subtract this amount at each level down the profile it is apparent that the numbers of eucalypts on Rottnest, during the early stages of swamp development, were little more than the number there at the present time.
4. The Casuarinas on Rottnest reached their maximum development during the middle of the record and then died out. They have subsequently been re-introduced into the settlement area by man.
5. The increase of *Melaleuca* (probably *M. pubescens*) on Rottnest commenced during the later stages of the swamp history.
6. The expansion of the grasses seems to have been an even more recent development.
7. The very high incidence of chenopods in the profile is probably due to water transport of the pollen into the swamp.

In spite of the widespread occurrence of *Acacia* on Rottnest and the presence of its pollen in the atmosphere, no fossil pollen was encountered in the Lighthouse swamp sediments. This anomalous situation has been observed in a number of swamps on the mainland, and has led the author to believe that *Acacia* pollen breaks down into its constituent nondescript massulae in the sediments, and thus becomes unrecognisable.

INDIRECT EVIDENCE

Indirect evidence of the past occurrence of *Casuarina* on the island is the presence of the trapdoor spider, *Idiosoma sigillatum* Cambridge, on Rottnest. This species has a "coastal" distribution on the mainland with a restricted association to *Casuarina* trees. On the other hand the closely related species, *I. nigrum* Main, is sometimes associated with *Casuarina* but usually with *Acacia* species such as Jam. Probably close to extinction on Rottnest, only a single male and female of *I. sigillatum* have been found running on the surface (Drs. A. R. and B. Y. Main, pers. comm.).

CHANGES IN THE ENVIRONMENT

The most important factor in the pre-history of the vegetation was the isolation of Rottnest from the mainland by eustatic change. Churchill (1959) showed that this event took place between 4,000 and 5,000 B.C. and since then rising sea level has reduced the area to an island, 7 miles long by 3 miles wide. By 3,000 B.C. sea level had risen to the same height as it is at present. That it continued to rise 10 feet higher, before falling to its present level, is shown by the following radiocarbon dated evidence:—

A beach deposit behind Pt. Peron 10 feet above M.S.L., 5,120 ± 130 years B.P. (ca. 3,000 B.C.).

Marine shell beds at Rottnest Island 9 feet above M.S.L., 3,950 ± 130 years B.P. (ca. 2,000 B.C.) (Fairbridge ms., cited by Hassell and Kneebone, 1959).

Ten foot sea platform in Victoria, 4,820 ± 200 years B.P. (ca. 3,000 B.C.) (Gill, 1955).

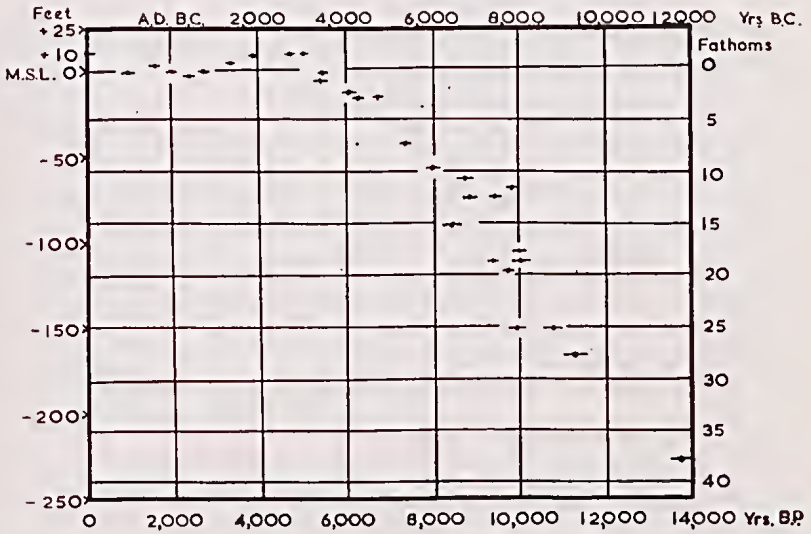

Fig. 3.—Changes in sea level since 12,000 years B.C.; compiled from data of Churchill; Fairbridge; Godwin, Suggate and Willis; Schofield.

Nine foot eustatic high in New Zealand (ca. 2,000 B.C.) (Schofield, 1960).

The change in sea level since 12,000 B.C. is shown in Fig. 3. The marine shell beds at Rottnest indicate a marine transgression to at least 9 feet above present sea level in 2,000 B.C. The reduction in the size of the island that followed its isolation from the mainland, the consequent deterioration in rainfall on Rottnest, loss of habitats and increased exposure to wind and salt, have led to the extinction of a *Eucalyptus-Casuarina* woodland, *Xanthorrhoea, Macrozamia,* and possibly *Banksia* and *Agonis* scrubs. The vegetation was thus reduced to elements of a *coastal complex* which, in historical times, has been altered further by clearing, selective cutting, firing, grazing and competition from introduced plants. The influence of these factors on the present vegetation of Rottnest Island has been discussed.

REFERENCES

CHURCHILL, D. M. 1959. Late Quaternary Eustatic Changes in the Swan River District. *Jour. Roy. Soc. W.A.,* 42: 53-55.

GILL, E. D. 1955. Radiocarbon dates for Australian archaeological and geological samples. *Aust. Jour. Sci.,* 18: 49-52.

HASSELL, C. W. and E. W. S. KNEEBONE. 1959. The Geology of Rottnest Island. B.Sc. Honours thesis in the library of the Geology Department, University of W.A.

SCHOFIELD, J. C. 1960. Sea level fluctuations during the past four thousand years. *Nature,* 185: 836.

STORR, G. M., J. W. GREEN and D. M. CHURCHILL. 1959. The vegetation of Rottnest Island. *Jour. Roy. Soc. W.A.,* 42: 70-71.

FROM FIELD AND STUDY

A Record of the Ox-eye Herring, *Megalops cyprinoides,* in Fresh Water in the Pilbara.—On August 23, 1956, my assistant A. C. Heyndyk collected a large fish, weighing 2 lb. 13 oz. and measuring 420 mm. from the snout to the middle of the caudal fork, in a small pool three miles south of Woodstock homestead, in the Pilbara district.

The specimen was identified by Mr. I. S. R. Munro, of the C.S.I.R.O. Marine Laboratory, Cronulla, N.S.W., as the Ox-eye Herring or Tarpon, *Megalops cyprinoides,* and the first record known to him of its occurrence away from coastal or brackish waters.

The pool was in the bed of the Yule River and had been isolated since the river ran in early March 1956. It was only some 10 ft. in diameter and about 3 ft. deep at its deepest point at the time the fish was caught. The length of the watercourse, between the pool and its mouth, west of Port Hedland, was in excess of 110 miles. The fish was very active and shared the pool with a large number of Spangled Perch, *Therapon unicolor.*

—E. H. M. EALEY, C.S.I.R.O., W.A. Regional Laboratory, Nedlands, W.A.